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Evaluation of CO_2 Mineral Trapping Rates in Aquifers based on experimental studies

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In this study, experiments on CO_2 -water-rock interaction have been conducted to elucidate the rock dissolution rate and to investigate long-term dissolution and precipitation phenomena in CO_2 reservoirs. The dissolution experiments are conducted by using semi-open experimental system constructed for this study. As the rock samples, in addition to the basalt which is considered as a suitable candidate rock formation for geochemical trapping of CO_2, tuffaceous sandstone (Hayama group: Kanagawa Prefecture) and three green tuff rocks (Tsugawa formation: Niigata Prefecture, Ushikiri formation: Shimane Prefecture, Daijima formation: Akita prefecture) from the Quaternary igneous rocks widely distributed in Japan were used.

From the eight-month-period of experiments, the facts found were that the composition of formation water will converge at the point where the rock dissolution and precipitation of secondary mineral are balanced and CO_2-water-rock interaction proceeds under a certain formation water composition. For this reason, the determination of rock dissolution rate (element release rate) under a certain formation water composition inherent in each rock sample is indispensable in order to predict the long-term progress of the reaction within CO_2 reservoirs.

Si release rate under a certain formation water composition that indicates the dissolution of silicate minerals from each rock sample is $29.8*10^{-2}$ mmol/kg-rock/day for basalt, $7.77*10^{-2}$ mmol/kg-rock/day for Tsugawa green tuff, $5.44*10^{-2}$ mmol/kg-rock/day for Ushikiri green tuff and $33.1*10^{-2}$ mmol/kg-rock/day for Daijima green tuff at the temperature of 50^oC.

The simulations on long-term CO_2 fixation efficiency (mineral trapping) in the CO_2 reservoir by using Ca, Mg and Fe release rates calculated from experiments were conducted. On the assumption that 1: CO_2 injection rate to be 2,000 ton/day 2: injection time period to be 50 years (total amount of injected CO_2 is 36,500,000 t) 3: target aquifer porosity 20% 4: CO_2 density 500 kg/m^3 5: injected CO_2 to groundwater volume ratio 1:2, the time required for mineral fixation of 36,500,000 tons of CO_2 is simulated to be about 180 years for basalt, about 5,100,000 tons of CO_2 fixed as a carbonate mineral in 200 years for Tsugawa green tuff, about 22,000,000 tons of CO_2 fixed in 200 years for Ushikiri green tuff and 3,900,000 tons of CO_2 fixed in 200 years for Daijima green tuff. at the temperature of 50^oC.

These results indicate that the mineral trapping rate in CO_2 reservoir is much faster than the results of previous studies and that geochemical trapping (mineral traping) is an important mechanism not only for long-term (10^3 - 10^4 years) security but also for shorter-term (- 10^2 years) security of CO_2 aquifer storage and is a significant indicator for the selection of potential storage candidate site.

Keywords: CCS, CO_2 geological storage, water-rock interaction, Green-Tuff, Basalt